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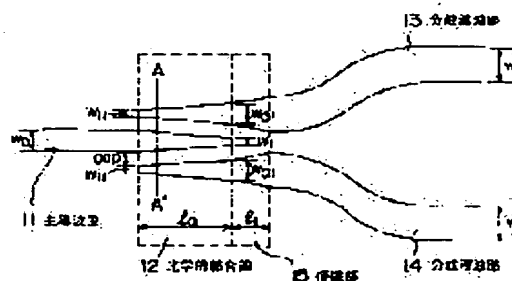
(54) BRANCHED MULTIPLEXING OPTICAL WAVEGUIDE CIRCUIT

(57)Abstract:

PROBLEM TO BE SOLVED: To obtain a Y-branched structure in which the clogging of interoptical waveguide gaps is not present, a manufacturing yield is improved and an excessive loss is sufficiently small.

SOLUTION: A gap is broadened without increasing a branching loss and the generating of bluntnesses and voids of gap parts are eliminated by allowing this waveguide to have an optical connecting part 12 in which a main waveguide 11 and two lines of branched waveguides 13, 14 are arranged while being made adjacent with a prescribed gap. When a light propagating the main waveguide 11 reaches the optical connection part 12, at the outset, the shifting is generated in between branched waveguides by a mode connection.

Thereafter, since as the light propagates the main waveguide 11, the light clogging state of the main waveguide 11 becomes weak to mitigate the mode connection having a strong wavelength-dependence and the waveguide becomes to be in a cutoff state, the waveguide becomes to lose the wavelength-dependence of the branching loss. Moreover, a complete light power shifting is realized by making the length of the optical connection part 12 to be equal to or longer than 500 μ m and then the branching loss is reduced.



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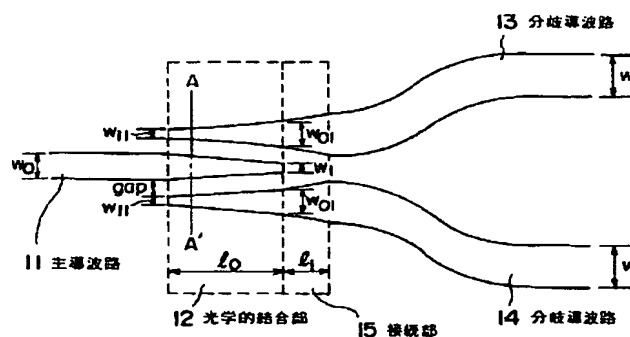
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(54)【発明の名称】 分岐合波光導波路回路

(57)【要約】

【課題】 光導波路間ギャップの閉塞がなく、製作歩留まりを向上させるとともに、過剰損失が十分小さいY分岐構造を提案する。

【解決手段】 主導波路11と2本の分岐導波路13, 14を所定の間隙(ギャップ)をもって近接されて配置する光学的結合部12を持つことにより、分岐損失を増大させることなく間隙を拡げることができ、ギャップ部の鈍りやボイドの発生をなくすることができる。主導波路11を伝搬する光は、光学的結合部12に到達すると、始めはモード結合により分岐導波路間に移行が起こる。その後、光が主導波路を伝搬するにつれ主導波路の光の閉じこめ状態が弱くなり、波長依存性の強いモード結合を緩和しカットオフの状態になるため、分岐損失の波長依存性をなくしている。さらに、光学的結合部の長さを500 μ m以上とすることにより完全な光パワーの移行が実現でき、分岐損失の低減を図っている。



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【特許請求の範囲】

【請求項 1】 基板上のクラッド中に形成された主導波路と該主導波路に光学的に結合する 2 本の分岐導波路とを有する分岐合波光導波路回路において、前記主導波路は、端部が主導波路から次第に縮小して延びる縮小導波路部を有し、前記縮小導波路部と前記分岐導波路とが接近して配置され光学的結合部を形成することを特徴とする分岐合波光導波路回路。

【請求項 2】 前記光学的結合部における前記縮小導波路部は、両側面にテーパ形状を有し、前記分岐導波路は、前記主導波路の各テーパ形状と対向する逆方向のテーパ形状の拡大導波路部を有することを特徴とする請求項 1 記載の分岐合波光導波路回路。

【請求項 3】 縮小導波路部と拡大導波路部とは 2. 0 μm 乃至 3. 5 μm の間隔を有することを特徴とする請求項 1 又は 2 記載の分岐合波光導波路回路。

【請求項 4】 光学的結合部は 500 μm 以上の長さを有することを特徴とする請求項 1、2 又は 3 記載の分岐合波光導波路回路。

【請求項 5】 光学的結合部における主導波路と分岐導波路を伝搬する光の伝搬方向は平行方向であることを特徴とする請求項 2、3 又は 4 記載の分岐合波光導波路回路。

【請求項 6】 光学的結合部における主導波路及び分岐導波路の最小導波路幅が 2 μm 以下であることを特徴とする請求項 2、3、4 又は 5 記載の分岐合波光導波路回路。

【請求項 7】 主導波路は光学的結合部にいたるまで基本モードの光を伝搬する導波路であることを特徴とする請求項 6 記載の分岐合波光導波路回路。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】 本発明は、基板上に形成された複数の光導波路を有し、光の分岐および合波を行う分岐合波光導波路回路に関する。

【0002】

【従来の技術】 導波路を用いた光集積回路において、分岐、合波の機能を有する光導波路回路は重要でかつ必要不可欠である。このような分岐合波光導波路回路としては、複数の分岐光導波路を有する Y 分岐光導波路回路が知られており、1×N スプリッタ等への応用がなされている。

【0003】 図 5 は、従来の Y 分岐光導波路回路を示す構成図である。

【0004】 図 5 の Y 分岐光導波路回路は、各導波路 21, 22, 23, 24 は、基板上のクラッド 2 中に埋め込まれている。また、導波路 21, 23, 24 の導波路幅が全て等しく、分岐導波路 23, 24 は曲率半径 r を有し、分岐導波路 23, 24 が始まる分岐点 25 の分岐導波路 23, 24 に囲まれた閉塞部分のギャップにおい

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ては先端が零であるような理想的な形状を有している。

【0005】 この Y 分岐光導波路回路の作製方法は図 6 に示すように、例えば、シリコン等の基板上 1 にクラッド層 2a、クラッド層 2a よりもわずかに屈折率の高いコア層 3 を順次堆積する。次いで所望の光導波路回路、例えば、図 2 の各導波路 21, 22, 23, 24 のように光導波路回路部分を残してエッチングにてコア層 3 を加工し、その後にクラッド層 2a を堆積して所望の光導波路回路を埋め込み、分岐合波光導波路回路が作製される。

【0006】 上述した Y 分岐光導波路回路においては、分岐合波の低損失化のためには、分岐点 25 の閉塞部分ギャップの先端形状が理想的な零に近くなるように作製される。

【0007】 しかしながら、現状の作製技術では、閉塞部分ギャップの先端の形状を零にすることは不可能であり、0. 5～1 μm と狭い幅をもつ。そのために、エッチングにて所望の光導波路回路となるように不要部分のコア層を取り除く時に、理想的には、閉塞部分ギャップの始まりも垂直に加工されなければならないが、閉塞しているために実際には精度良く加工することが困難であり、閉塞されたギャップ部分に取り除くべきコア層が残留して図 7 に示すように鈍りが生じ、分岐損失が増大し、歩留まりが低下する。また、精度よく加工された場合においても、閉塞部分の 0. 5～1 μm の狭いギャップをクラッド層 2a で埋め込む時に、図 8 に示すようにギャップ部にボイドと呼ばれる空気層 26 が発生し、このボイドが分岐損失を増大し、歩留まりが低下する。また、作製上の上記問題を解決するために、単純に分岐点（閉塞部分）のギャップを拡げるだけでは、かえって分岐損失が増大し、低損失の分岐合波光導波路回路を構成することは困難である。ここで、図 7、図 8 は図 2 における分岐導波路 23, 24 に囲まれた閉塞したギャップの分岐点 25 の近傍の B-B' 断面図である。

【0008】 上述したような課題を解決するために、特開平 4-70605 号公報によれば、図 9 のような分岐合波光導波路回路が考案されている。主導波路 21 と主導波路 21 から拡大して延びる拡大導波路 22 と拡大導波路と所定の間隙をもって分離される分岐導波路 23, 24 からなり、かつ分岐導波路 23, 24 も所定の間隙をもって分離されている構造を有する分岐合波光導波路回路である。

【0009】

【発明が解決しようとする課題】 上述のように、図 5 に示す Y 分岐光導波路回路は閉塞部分のギャップのコア層の残留、ギャップの鈍り、又はボイドの発生等の構造上の不完全性を生じやすく、分岐損失が増大し歩留まりが低下することから作製上不利である点で問題があった。また、主導波路と分岐導波路の間にギャップを有する図 9 に示す分岐合波光導波路回路は、光学的結合部の構造

は図5のY分岐光導波路回路と本質的の同じ拡大導波路22を有しており、Y分岐光導波路回路の主導波路と分岐導波路の結合部を直線状に一部切断した構造としたものである。しかしながら、このような構造では、鋭角の先端部の製作は困難であるのみならず、光の伝搬についても、主導波路21の基本モードの伝搬光が拡大導波路22において高次モードとなり、更に分岐導波路23、24では基本モードで伝搬することになるため、伝搬モードの相互の変換と間隙での光学的結合とにより、充分良好な分岐損失特性及び波長依存性は得られず、分岐合波特性の再現の安定性にも欠ける。特に、拡大導波路22の端面220、分岐導波路23の端面230及び分岐導波路24の端面240等、主導波路21の導波路の軸とのなす角度 θ が小さくなるほどこれが顕著に現れ分岐損失は増大し、また、分岐特性の再現性が大きく悪化する点で難点がある。

【0010】本発明の目的は、分岐合波の光学的結合部の導波路の製作上の不完全性等が緩和され、製作が容易で過剰損失が充分小さく、且つ過剰損失の波長依存性が良好で特性の再現性の高い分岐合波光導波回路を提供することにある。

【0011】

【課題を解決するための手段】本発明は分岐合波光導波路回路は、基板上のクラッド中に形成された主導波路と該主導波路に光学的に結合する2本の分岐導波路とを有する分岐合波光導波路回路において、前記主導波路は、端部が主導波路から次第に縮小して延びる縮小導波路部を有し、前記縮小導波路部と前記分岐導波路とが接近して配置され光学的結合部を形成することを特徴とする。また、前記光学的結合部における前記縮小導波路部は、両側面にテーパ形状を有し、前記分岐導波路は、前記主導波路の各テーパ形状と対向する逆方向のテーパ形状の拡大導波路部を有することを特徴とする。

【0012】そして、本発明の縮小導波路部と拡大導波路部とは $2.0\mu\text{m}$ 乃至 $3.5\mu\text{m}$ の間隔を有するのが好適であり、光学的結合部は $500\mu\text{m}$ 以上の長さとするのが好適である。

【0013】更に具体的には、分岐合波光導波路回路の構造において、2本の分岐導波路間の閉塞するギャップ部をなくし、主導波路と2本の分岐導波路が近接して配置されている光学的結合部を有し、その光学的結合部において、主導波路は、導波路幅が徐々に狭くなるテーパ形状を有し、分岐導波路は、主導波路と逆に導波路幅が徐々に広がるテーパ形状を有する。その光学的結合部の長さは、光学的結合部の主導波路と2本の分岐導波路の幅の組み合わせにより必要とされる最小の長さが存在するが、少なくとも $500\mu\text{m}$ 以上の長さを有する。また、その光学的結合部において、主導波路と2本の分岐導波路の間隔(gap)を $2.0\sim 3.5\mu\text{m}$ に設定する。また、光学的結合部における最小の導波路幅は、カ

ットオフの状態に近づけて光の移行を行うために $2\mu\text{m}$ 以下である。また、主導波路は光学的結合部に至るまでは基本モードのみが伝搬するように導波路幅、深さが決められている。

【0014】また、光学的結合部において、主導波路と2本の分岐導波路を伝搬する光の伝搬方向が平行であるように導波路の幅を決定し配置する。

【0015】導波路間の閉塞するギャップをなくし、主導波路と2本の分岐導波路を所定の間隙(ギャップ)をもって近接されて配置する光学的結合部を持つことにより、分岐損失を増大させることなく間隙を拡げることができ、ギャップ部の鈍りやボイドの発生をなくすることができる。また、光学的結合部において上述したような構造をとることにより、主導波路を伝搬する光は、光学的結合部に到達すると、始めはモード結合により分岐導波路間に移行が起こる。その後、光が主導波路を伝搬するにつれ主導波路の光の閉じこめ状態が弱くなり、波長依存性の強いモード結合を緩和しカットオフの状態に近くなるため、分岐損失の波長依存性をなくしている。さらに、光学的結合部の長さを $500\mu\text{m}$ 以上とすることにより完全な光パワーの移行が実現でき、分岐損失の低減を図れる。

【0016】また、上述したように主導波路が基本モードのみを伝搬できる導波路幅、深さにしたり、結合部において、主導波路と2本の分岐導波路とを伝搬する光の伝搬方向が平行であるように導波路の幅を決定し配置することにより、分岐損失の増大を抑制し、低損失かつ安定な特性を有する分岐合波光導波路回路を作製することができる。

【0017】

【発明の実施の形態】図1は、本発明の分岐合波光導波路回路の一実施の形態を示す構成図である。

【0018】主導波路11は、光学的結合部12に至るまでのある長さにおいては導波路幅(W_0)が一定でかつ基本モードのみが伝搬する導波路である。

【0019】光学的結合部において、主導波路11は導波路幅が W_0 から W_1 に($W_0 > W_1$)徐々に変わるようなテーパ構造を有している。また、光学的結合部12における分岐導波路13、14は主導波路とは異なる方向で導波路幅が W_{11} から W_{01} ($W_{11} < W_{01}$)に徐々に変わるようなテーパ構造を有している。テーパ構造における主導波路11と分岐導波路13、14の最小幅 W_1 と W_{11} は、導波路幅が狭くなる方向にテーパ導波路を伝搬する光が、カットオフとなるようにできるだけ狭い($2\mu\text{m}$ 以下)方が望ましい。また、光学的結合部12における主導波路および分岐導波路の各最大幅(W_0 、 W_{01})、最小限(W_1 、 W_{11})は、かならずしも同じである必要はないが、各導波路幅11、13、14が同じである方が望ましい。すなわち、光学的結合部における主導波路11と分岐導波路13、14の軸が平行である

ことが望ましい。

【0020】光学的結合部12では、主導波路11と分岐導波路13, 14は、所定の間隔(gap)をもって分離されている。そのgapは導波路の作製の点からみて2.0 μ m以上にすることが望ましく、また特性の点からは3.5 μ m以下にすることが望ましい。また、光学的結合部12は、分岐損失を小さくするためにある長さ l_0 以上必要である。その長さは、光学的結合部12における主導波路11および分岐導波路13, 14の最大幅(W_0 、 W_{01})、最小幅(W_1 、 W_{11})の組み合わせにより変化するが、少なくとも500 μ m以上にすることが望ましい。

【0021】分岐導波路13, 14は、上述したテーバ構造を有する光学的結合部12とこれとは独立して曲率半径rを持つ曲がり導波路から構成されている。このとき、分岐部12のテーバ導波路の最も幅の広い導波路幅 W_{01} と曲がり導波路の幅Wはかならずしも同じである必要はなく、曲がり導波路幅が広くてもよい。このときには、1つの分岐導波路のテーバ導波路部と曲がり導波路部の間で低損失で光が伝搬するように、光学的結合部12とは独立で全く別なテーバ導波路を光学的結合部12と曲がり導波路の間に接続する構成としてもよい。また、曲がり導波路部は、分岐導波路13, 14が互いに離れるような斜め導波路でもよい。

【0022】主導波路11を伝搬してきた光は、光学的結合部12において始めはモード結合により各分岐導波路13, 14へと光の移行が起こり、主導波路11の終端部では、主導波路11のテーバ形状の終端で光がカットオフ状態となり、各分岐導波路13, 14へと移行する。このように、光の移行にカットオフ作用を用いることにより、分岐損失の波長依存性は非常に小さくなる。また、光学的結合部12における主導波路11と分岐導波路13, 14を伝搬する光の方向は平行であることが望ましい。

【0023】図1に示すような分岐合波光導波路回路の作製は図6に示す方法で行うことができる。具体的には、基板1上にクラッド2a、コア層3を例えばTEOS- O_3 系AP-CVDにて順次堆積していく。次いで反応性イオンエッチングにより上述した光導波路回路となるように不要なコア層3を除去する。その後、このコア層3を埋め込むようにクラッド層2aを堆積することにより光導波路回路が作製される。

【0024】図3、図4に本発明による分岐合波光導波路回路を用いた分岐過剰損失のBPMシミュレーションにて計算した特性の一例を示す。

【0025】図3は、光学的結合部の主導波路11と分岐導波路13, 14との間のgapをパラメータとした、分岐過剰損失の光学的結合部12の長さ l_0 依存性を示す。伝搬波長 λ は1.27 μ m、比屈折率差 Δ は0.40%、主導波路11の幅 W_0 は3 μ m、光学的結

合部12における主導波路11および分岐導波路13の最大幅 W_0 、 W_{01} は3 μ m($W_0 = W_{01}$)、最小幅 W_1 、 W_{11} は1 μ m($W_1 = W_{11}$)、分岐導波路13, 14の光学的結合部12と曲がり導波路を接続するための導波路の長さは500 μ mである。光学的結合部12の長さが500 μ m以上では、分岐過剰損失が0.2dB以下と小さい値が得られている。

【0026】図4は、光学的結合部12の主導波路11と分岐導波路13, 14との間のgapをパラメータとした分岐過剰損失の伝搬波長依存性を示す。光学的結合部の長さ l_0 は500 μ mその他の条件は、図3と同じである。波長1.27 μ mから1.57 μ mまでで分岐過剰損失が0.2dB以下と非常に小さい値が得られている。

【0027】

【発明の効果】本発明によれば、分岐合波光導波路回路におけるギャップの閉塞部分をなくしており、導波路間の最小ギャップを広げることができるから、製作時の導波路のギャップ部のコア層の残留、ギャップの鈍りやボイドの発生をなくし、更に、極めて高い製作精度を必要としないため、製作が容易であり歩留まりも従来構造に比べて大幅に向上できる。

【0028】また、主導波路を光学的結合部においてテーバ形状のような主導波路の端部から外径が次第に縮小して延びる縮小導波路構造としているから、テーバ等、縮小導波路の始まり部分では主導波路11から分岐導波路13, 14にモード結合により光が移行し、また、縮小導波路の終端に近づくにつれ光の閉じこめ状態が弱くなり、カットオフ状態となることにより光が分岐導波路2, 3に移行する。このため、主導波路から分岐導波路への光パワーの移行が効率的に行われ、ギャップ間隔を広げても過剰損失の増大を抑制することができる。また、本発明では主導波路のカットオフによる光の移行をも利用しているのでモード結合を緩和でき波長依存性を小さくすることができる。

【0029】更に、光学的結合部において導波路の外径が高次モードを生ずるような拡大構造を持たないため、高次モードの発生と導波路間のモード間の不整合に起因する過剰損失は皆無となる。

【0030】以上のように、本発明によれば前記構成を有することから、導波路幅、ギャップ、テーバ等の縮小、拡大導波路及びその光学的結合部の長さを設定することにより、歩留まりがよく、分岐過剰損失を小さくでき、特性の波長依存性が小さくでき、且つ特性の再現性の良い分岐結合光導波路回路が得られる。

【図面の簡単な説明】

【図1】本発明の分岐合波光導波路回路の一実施の形態を示す図である。

【図2】本実施の形態のA-A'における断面図を示す図である。

【図3】本実施の形態におけるBPFシミュレーションによる過剰損失の結合部長さ (l_0) 依存性の特性の一例を示す図である。

【図4】本実施の形態におけるBPFシミュレーションによる過剰損失の波長依存性の特性の一例を示す図である。

【図5】従来の分岐合波光導波路回路の一例を示す図である。

【図6】分岐合波光導波路回路の製造方法の一例を示す図である。

【図7】従来の分岐合波光導波路回路のB-B'における断面図を示す図である。

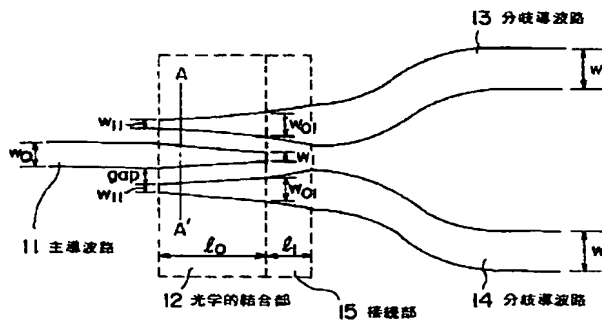
【図8】従来の分岐合波光導波路回路のB-B'における断面図を示す図である。

【図9】従来の分岐合波光導波路回路の他の例を示す図である。

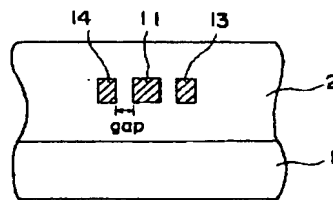
【符号の説明】

- 1 基板
- 2 クラッド
- 3 コア層
- 11, 21 主導波路
- 12 光学的結合部
- 13, 14, 23, 24 分岐導波路
- 10 15 接続部
- 22 拡大導波路
- 24 分岐点
- 26 ボイド

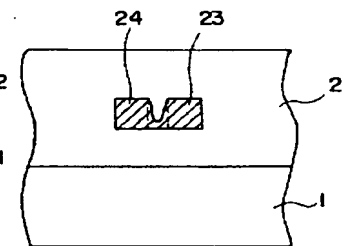
【図1】



【図2】

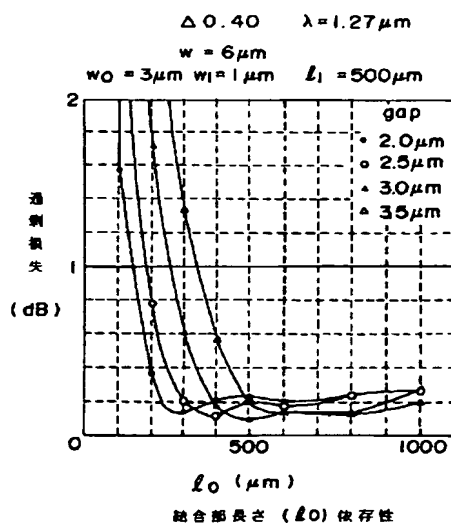


【図7】

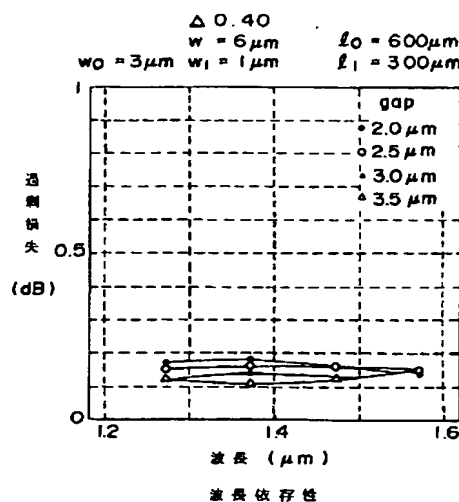


(B-B' 断面)

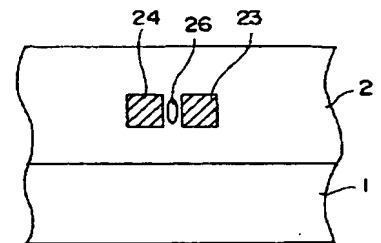
【図3】



【図4】

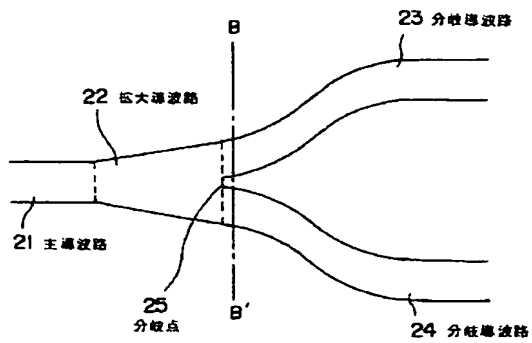


【図8】

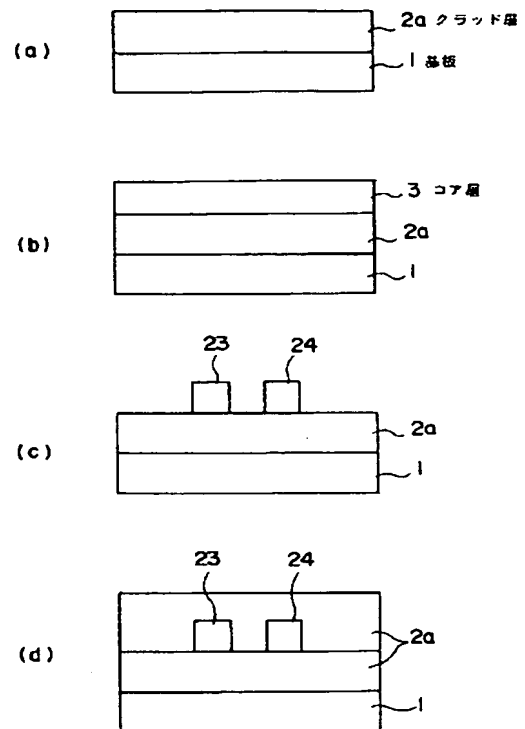


(B-B' 断面)

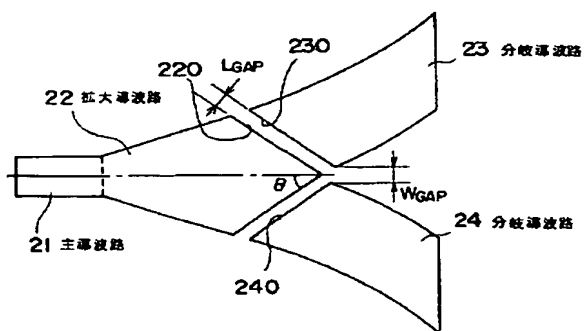
【図5】



【図6】



【図9】



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CLAIMS

[Claim(s)]

[Claim 1] It is the branching multiplexing optical waveguide circuit characterized by to have the contraction waveguide section to which an edge reduces said main waveguide gradually from the main waveguide in the branching multiplexing optical waveguide circuit which has two branching waveguides optically combined with the main waveguide and this main waveguide formed into the clad on a substrate, and it extends, for said contraction waveguide section and said branching waveguide to approach, to be arranged, and to form the optical-coupling section.

[Claim 2] It is the branching multiplexing optical waveguide circuit according to claim 1 characterized by for said contraction waveguide section in said optical coupling section having a taper configuration in a both-sides side, and said branching waveguide having the expansion waveguide section of each taper configuration of said main waveguide, and the taper configuration of the hard flow which counters.

[Claim 3] The contraction waveguide section and the expansion waveguide section are a branching multiplexing optical waveguide circuit according to claim 1 or 2 characterized by having spacing of 2.0 micrometers thru/or 3.5 micrometers.

[Claim 4] The optical coupling section is a branching multiplexing optical waveguide circuit according to claim 1, 2, or 3 characterized by having die length of 500 micrometers or more.

[Claim 5] The propagation direction of the light which spreads the main waveguide and branching waveguide in the optical coupling section is a branching multiplexing optical waveguide circuit the claims 2 and 3 characterized by the parallel thing, or given in four.

[Claim 6] The branching multiplexing optical waveguide circuit according to claim 2, 3, 4, or 5 characterized by the minimum waveguide width of face of the main waveguide in the optical coupling section and branching waveguide being 2 micrometers or less.

[Claim 7] The main waveguide is a branching multiplexing optical waveguide circuit according to claim 6 characterized by being the waveguide which spreads the light of a basic mode until it results in the optical coupling section.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention has two or more optical waveguides formed on the substrate, and relates to the branching multiplexing optical waveguide circuit which performs branching and multiplexing of light.

[0002]

[Description of the Prior Art] In the optical integrated circuit using waveguide, the optical waveguide circuit which has the function of branching and multiplexing is important, and indispensable. As such a branching multiplexing optical waveguide circuit, the Y branch optical waveguide circuit which has two or more branching optical waveguides is known, and the application to a 1xN splitter etc. is made.

[0003] Drawing 5 is the block diagram showing the conventional Y branch optical waveguide circuit.

[0004] Each waveguides 21, 22, 23, and 24 are embedded for the Y branch optical waveguide circuit of drawing 5 into the clad 2 on a substrate. Moreover, all of the waveguide width of face of waveguides 21, 23, and 24 are equal, and the branching waveguides 23 and 24 have radius of curvature r, and have an ideal configuration [as / whose tip is zero] in the gap of the lock out part surrounded by the branching waveguides 23 and 24 of the branch point 25 when the branching waveguides 23 and 24 start.

[0005] The production approach of this Y branch optical waveguide circuit carries out the sequential deposition of the core layer 3 with a slightly high refractive index substrate top 1, such as silicon, as shown in drawing 6 rather than cladding layer 2a and cladding layer 2a. Subsequently, it leaves an optical waveguide circuit part like the desired optical waveguide circuit 21, 22, 23, and 24, for example, each waveguides of drawing 2, and a core layer 3 is processed by etching, cladding layer 2a is deposited after that, a desired optical waveguide circuit is embedded, and a branching multiplexing optical waveguide circuit is produced.

[0006] In the Y branch optical waveguide circuit mentioned above, for low-loss-izing of branching multiplexing, it is produced so that the tip configuration of the lock out partial gap of the branch point 25 may become close to ideal zero.

[0007] However, with the present production technique, it is impossible to make the configuration at the tip of a lock out partial gap into zero, and it has 0.5-1 micrometer and narrow width of face. Therefore, as the core layer which should be removed into the gap part which it is difficult to process it with a sufficient precision in fact [since it blockades] although the beginning of a lock out partial gap must also be processed perpendicularly ideally, and was blockaded remains when removing the core layer of a garbage so that it may become a desired optical waveguide circuit by etching, and shown in drawing 7, **** arises, branching loss increases, and the yield falls. Moreover, when are processed with a sufficient precision and embedding the narrow gap of 0.5-1 micrometer of a lock out part by cladding layer 2a, as shown in drawing 8, the air space 26 called a void to the gap section occurs, this void increases branching loss, and the yield falls. Moreover, in order to solve the above-mentioned problem on production, it is difficult for branching loss to increase on the contrary and to constitute the branching multiplexing optical waveguide circuit of low loss only by extending the gap of the branch point (lock

out part) simply. Here, drawing 7 and drawing 8 are the B-B' sectional views near the branch point 25 of the blockaded gap which was surrounded by the branching waveguides 23 and 24 in drawing 2.

[0008] In order to solve a technical problem which was mentioned above, according to JP,4-70605,A, a branching multiplexing optical waveguide circuit like drawing 9 is devised. It is the branching multiplexing optical waveguide circuit which has the structure where consist of the expansion waveguide 22 and expansion waveguide which are expanded and prolonged from the main waveguide 21 and the main waveguide 21, and branching waveguides 23 and 24 separated with a predetermined gap, and the branching waveguides 23 and 24 are also separated with the predetermined gap.

[0009]

[Problem(s) to be Solved by the Invention] As mentioned above, the Y branch optical waveguide circuit of a gap [the residual of the core layer of the gap of a lock out part and] shown in drawing 5 becomes blunt, or tended to produce the incompleteness on structures, such as generating of a void, and since branching loss increased and the yield fell, it had a problem at the disadvantageous point on production. Moreover, the branching multiplexing optical waveguide circuit shown in drawing 9 which has a gap between the main waveguide and branching waveguide has the Y branch optical waveguide circuit of drawing 5, and an essential target's same expansion waveguide 22, and makes structure of the optical coupling section the structure which cut the bond part of the main waveguide of a Y branch optical waveguide circuit, and branching waveguide in part in the shape of a straight line. however, with such structure, manufacture of the point of an acute angle about propagation of light it is not only difficult, but In order that the propagation light of the basic mode of the main waveguide 21 serves as the higher mode in the expansion waveguide 22 and may spread by the basic mode by the branching waveguides 23 and 24 further, A sufficiently good branching loss property and a wavelength dependency are not acquired by mutual conversion of propagating mode, and the optical coupling in a gap, but lack also in the stability of reappearance of a branching multiplexing property by them. A difficulty has expression branching loss in that this increases notably, so that the include angle theta with the shaft of the waveguide of the end-face 240 grade of the end face 220 of the expansion waveguide 22, the end face 230 of the branching waveguide 23, and the branching waveguide 24 and the main waveguide 21 to make becomes small especially, and the repeatability of a branching property gets worse greatly.

[0010] The incompleteness on manufacture of the waveguide of the optical coupling section of branching multiplexing etc. is eased, the purpose of this invention is easy to manufacture, its superfluous loss is small enough, and its wavelength dependency of superfluous loss is good, and is to offer the high branching multiplexing photoconductive wave circuit of the repeatability of a property.

[0011]

[Means for Solving the Problem] In the branching multiplexing optical waveguide circuit which has two branching waveguides which this invention combines with the main waveguide and this main waveguide by which the branching multiplexing optical waveguide circuit was formed into the clad on a substrate optically, said main waveguide is characterized by to have the contraction waveguide section to which an edge contracts gradually and extends from the main waveguide, and for said contraction waveguide section and said branching waveguide to approach, to be arranged, and to form the optical-coupling section. Moreover, said contraction waveguide section in said optical coupling section has a taper configuration in a both-sides side, and said branching waveguide is characterized by having the expansion waveguide section of each taper configuration of said main waveguide, and the taper configuration of the hard flow which counters.

[0012] And it is suitable for the contraction waveguide section and the expansion waveguide section of this invention to have spacing of 2.0 micrometers thru/or 3.5 micrometers, and it is suitable for the optical coupling section to consider as die length of 500 micrometers or more.

[0013] Furthermore, in the structure of a branching multiplexing optical waveguide circuit, the gap section blockaded between two branching waveguides is specifically lost, it has the optical coupling section by which the main waveguide and two branching waveguides are arranged by approaching, the main waveguide has the taper configuration to which waveguide width of face becomes narrow gradually in the optical coupling section, and branching waveguide has the taper configuration to which

waveguide width of face spreads gradually in the main waveguide and reverse. The die length of the optical coupling section has die length of at least 500 micrometers or more, although the minimum die length needed by the combination of the width of face of the main waveguide of the optical coupling section and two branching waveguides exists. Moreover, in the optical coupling section, spacing (gap) of the main waveguide and two branching waveguides is set as 2.0-3.5 micrometers. Moreover, the minimum waveguide width of face in the optical coupling section is 2 micrometers or less, in order to bring close to the condition of a cut-off and to shift light. Moreover, waveguide width of face and the depth are decided that only a basic mode spreads until the main waveguide results in the optical coupling section.

[0014] Moreover, in the optical coupling section, the propagation direction of the light which spreads the main waveguide and two branching waveguides determines and arranges the width of face of waveguide so that in parallel.

[0015] By losing the gap blockaded between waveguides and having the optical coupling section which approaches with a predetermined gap (gap) and arranges the main waveguide and two branching waveguides, a gap can be extended without increasing branching loss, the gap section becomes blunt, and generating of a ** void can be abolished. Moreover, if the light which spreads the main waveguide by taking structure which was mentioned above in the optical coupling section reaches the optical coupling section, shift will take place between branching waveguides by mode coupling in the beginning. Then, the light of the main waveguide shut up, and since it becomes weak, and a condition eases mode coupling with a strong wavelength dependency and becomes close to the condition of a cut-off, the wavelength dependency of branching loss has been abolished as light spreads the main waveguide. Furthermore, by setting the die length of the optical coupling section to 500 micrometers or more, shift of perfect optical power can be realized and reduction of branching loss can be aimed at.

[0016] Moreover, as mentioned above, when it is made the waveguide width of face and the depth in which the main waveguide can spread only a basic mode, or the propagation direction of the light which spreads the main waveguide and two branching waveguides determines and arranges the width of face of waveguide in a bond part so that in parallel, increase of branching loss can be controlled, and the branching multiplexing optical waveguide circuit which has low loss and a stable property can be produced.

[0017]

[Embodiment of the Invention] Drawing 1 is the block diagram showing the gestalt of 1 operation of the branching multiplexing optical waveguide circuit of this invention.

[0018] The main waveguide 11 has fixed waveguide width of face (W_0) in the die length which is until it results in the optical coupling section 12, and is waveguide which only a basic mode spreads.

[0019] the optical coupling section -- setting -- the main waveguide 11 -- waveguide width of face -- W_0 from -- W_1 It has taper structure which changes gradually ($W_0 > W_1$). Moreover, the branching waveguides 13 and 14 in the optical coupling section 12 have taper structure which changes waveguide width of face to W_0 ($W_1 < W_0$) gradually from W_1 towards differing from the main waveguide. The minimum width of face W_1 of the main waveguide 11 and the branching waveguides 13 and 14 in taper structure W_1 has the desirable way that the light which spreads taper waveguide in the direction in which waveguide width of face becomes narrow is narrow as it can be cut off (2 micrometers or less). Moreover, although each maximum width (W_0 , W_0) of the main waveguide in the optical coupling section 12 and branching waveguide and the minimum (W_1 , W_1) do not necessarily need to be the same, its one where each waveguide width of face 11, 13, and 14 is the more nearly same is desirable. That is, it is desirable for the shaft of the main waveguide 11 in the optical coupling section and the branching waveguides 13 and 14 to be parallel.

[0020] In the optical coupling section 12, the main waveguide 11 and the branching waveguides 13 and 14 have predetermined spacing (gap), and are separated. In terms of production of waveguide, as for the gap, it is desirable to make it 2.0 micrometers or more, and it is desirable to make it 3.5 micrometers or less from the point of a property. Moreover, the optical coupling section 12 is the die length l_0 which exists in order to make branching loss small. It is above required. Although the die length changes with

the combination of the maximum width (W_0 , W_{01}) of the main waveguide 11 in the optical coupling section 12, and the branching waveguides 13 and 14, and the minimum width of face (W_1 , W_{11}), it is desirable to make it at least 500 micrometers or more.

[0021] The branching waveguides 13 and 14 consist of deflection waveguides in which the optical coupling section 12 which has the taper structure mentioned above, and this have radius of curvature r independently. At this time, it may bend with the waveguide width of face W_{01} with the widest width of face of the taper waveguide of a tee 12, and the width of face W of waveguide does not necessarily need to be the same, and its deflection waveguide width of face may be wide. At this time, it is good also as a configuration which turns at taper waveguide independent [the optical coupling section 12] and completely different with the optical coupling section 12, and is connected between waveguides so that it may bend with the taper waveguide section of one branching waveguide and light may spread by low loss between the waveguide sections. Moreover, slanting waveguide which the branching waveguides 13 and 14 leave mutually is sufficient as the deflection waveguide section.

[0022] In the optical coupling section 12, shift of light takes place to each branching waveguides 13 and 14 by mode coupling in the beginning, in the trailer of the main waveguide 11, light will be in a cut-off condition at the termination of the taper configuration of the main waveguide 11, and the light which has spread the main waveguide 11 will shift to each branching waveguides 13 and 14. Thus, the wavelength dependency of branching loss becomes very small by using a cut-off operation for shift of light.

Moreover, the parallel thing of the direction of the light which spreads the main waveguide 11 and the branching waveguides 13 and 14 in the optical coupling section 12 is desirable.

[0023] Production of a branching multiplexing optical waveguide circuit as shown in drawing 1 can be performed by the approach shown in drawing 6. Specifically, they are clad 2a and a core layer 3 on a substrate 1 TEOS-O3 Sequential deposition is carried out in system AP-CVD. Subsequently, the unnecessary core layer 3 is removed so that it may become the optical waveguide circuit mentioned above by reactive ion etching. Then, an optical waveguide circuit is produced by depositing cladding layer 2a so that this core layer 3 may be embedded.

[0024] An example of the property calculated to drawing 3 and drawing 4 in the BPM simulation of the overbranching loss using the branching multiplexing optical waveguide circuit by this invention is shown.

[0025] Drawing 3 is the die length l_0 of the optical coupling section 12 of overbranching loss which made the parameter gap between the main waveguide 11 of the optical coupling section, and the branching waveguides 13 and 14. A dependency is shown. The propagation wavelength λ is 1.27 micrometers and relative index difference Δ is the width of face W_0 of 0.40% and the main waveguide 11. 3 micrometers, The maximum width W_0 of the main waveguide 11 in the optical coupling section 12, and the branching waveguide 13, The die length of the waveguide for W_{01} turning at the 3-micrometer ($W_0 = W_{01}$) minimum width of face W_1 and W_{11} with the optical coupling section 12 of 1 micrometer ($W_1 = W_{11}$) and the branching waveguides 13 and 14, and connecting waveguide is 500 micrometers. By 500 micrometers or more, the value with as small overbranching loss as 0.2dB or less is acquired for the die length of the optical coupling section 12.

[0026] Drawing 4 shows the propagation wavelength dependency of the overbranching loss which made the parameter gap between the main waveguide 11 of the optical coupling section 12, and the branching waveguides 13 and 14. The die length l_0 of the optical coupling section The conditions of 500-micrometer others are the same as drawing 3. The value with very as small overbranching loss as 0.2dB or less is acquired by the wavelength of 1.27 micrometers to 1.57 micrometers.

[0027]

[Effect of the Invention] Since according to this invention the lock out part of the gap in a branching multiplexing optical waveguide circuit is lost, the minimum gap between waveguides can be extended, the residual of the core layer of the gap section of the waveguide at the time of manufacture and a gap become blunt, generating of a ** void is abolished and a further very high manufacture precision is not needed, manufacture is easy and yield's can improve sharply compared with structure conventionally.

[0028] Moreover, since the main waveguide is made into the contraction waveguide structure where an

outer diameter contracts gradually and is prolonged from the edge of main waveguide like a taper configuration in the optical coupling section. In the beginning part of contraction waveguides, such as a taper, light shifts to the branching waveguides 13 and 14 by mode coupling from the main waveguide 11, and light shifts to the branching waveguides 2 and 3 by light's shutting up, and a condition's becoming weak and being in a cut-off condition as the termination of contraction waveguide is approached. For this reason, shift of the optical power from the main waveguide to branching waveguide is performed efficiently, and even if it extends gap spacing, increase of superfluous loss can be controlled. Moreover, in this invention, since shift of the light by the cut-off of the main waveguide is also used, mode coupling can be eased and a wavelength dependency can be made small.

[0029] Furthermore, since it does not have the expansion structure where the outer diameter of waveguide produces the higher mode in the optical coupling section, the superfluous loss resulting from generating of the higher mode and the mismatching between the modes between waveguides becomes that there is nothing.

[0030] As mentioned above, since it has said configuration according to this invention, by setting up the die length of contraction of waveguide width of face, a gap, a taper, etc., expansion waveguide, and its optical coupling section, the yield is good and can make overbranching loss small, the wavelength dependency of a property is made small and the good branching joint optical waveguide circuit of the repeatability of a property is obtained.

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TECHNICAL FIELD

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PRIOR ART

[Description of the Prior Art] In the optical integrated circuit using waveguide, the optical waveguide circuit which has the function of branching and multiplexing is important, and indispensable. As such a branching multiplexing optical waveguide circuit, the Y branch optical waveguide circuit which has two or more branching optical waveguides is known, and the application to a 1xN splitter etc. is made.

[0003] Drawing 5 is the block diagram showing the conventional Y branch optical waveguide circuit.

[0004] Each waveguides 21, 22, 23, and 24 are embedded for the Y branch optical waveguide circuit of drawing 5 into the clad 2 on a substrate. Moreover, all of the waveguide width of face of waveguides 21, 23, and 24 are equal, and the branching waveguides 23 and 24 have radius of curvature r, and have an ideal configuration [as / whose tip is zero] in the gap of the lock out part surrounded by the branching waveguides 23 and 24 of the branch point 25 when the branching waveguides 23 and 24 start.

[0005] The production approach of this Y branch optical waveguide circuit carries out the sequential deposition of the core layer 3 with a slightly high refractive index substrate top 1, such as silicon, as shown in drawing 6 rather than cladding layer 2a and cladding layer 2a. Subsequently, it leaves an optical waveguide circuit part like the desired optical waveguide circuit 21, 22, 23, and 24, for example, each waveguides of drawing 2, and a core layer 3 is processed by etching, cladding layer 2a is deposited after that, a desired optical waveguide circuit is embedded, and a branching multiplexing optical waveguide circuit is produced.

[0006] In the Y branch optical waveguide circuit mentioned above, for low-loss-izing of branching multiplexing, it is produced so that the tip configuration of the lock out partial gap of the branch point 25 may become close to ideal zero.

[0007] However, with the present production technique, it is impossible to make the configuration at the tip of a lock out partial gap into zero, and it has 0.5-1 micrometer and narrow width of face. Therefore, as the core layer which should be removed into the gap part which it is difficult to process it with a sufficient precision in fact [since it blockades] although the beginning of a lock out partial gap must also be processed perpendicularly ideally, and was blockaded remains when removing the core layer of a garbage so that it may become a desired optical waveguide circuit by etching, and shown in drawing 7, **** arises, branching loss increases, and the yield falls. Moreover, when are processed with a sufficient precision and embedding the narrow gap of 0.5-1 micrometer of a lock out part by cladding layer 2a, as shown in drawing 8, the air space 26 called a void to the gap section occurs, this void increases branching loss, and the yield falls. Moreover, in order to solve the above-mentioned problem on production, it is difficult for branching loss to increase on the contrary and to constitute the branching multiplexing optical waveguide circuit of low loss only by extending the gap of the branch point (lock out part) simply. Here, drawing 7 and drawing 8 are the B-B' sectional views near the branch point 25 of the blockaded gap which was surrounded by the branching waveguides 23 and 24 in drawing 2.

[0008] In order to solve a technical problem which was mentioned above, according to JP,4-70605,A, a branching multiplexing optical waveguide circuit like drawing 9 is devised. It is the branching multiplexing optical waveguide circuit which has the structure where consist of the expansion waveguide 22 and expansion waveguide which are expanded and prolonged from the main waveguide

21 and the main waveguide 21, and branching waveguides 23 and 24 separated with a predetermined gap, and the branching waveguides 23 and 24 are also separated with the predetermined gap.

[Translation done.]

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EFFECT OF THE INVENTION

[Effect of the Invention] Since according to this invention the lock out part of the gap in a branching multiplexing optical waveguide circuit is lost, the minimum gap between waveguides can be extended, the residual of the core layer of the gap section of the waveguide at the time of manufacture and a gap become blunt, generating of a ** void is abolished and a further very high manufacture precision is not needed, manufacture is easy and yield's can improve sharply compared with structure conventionally. [0028] Moreover, since the main waveguide is made into the contraction waveguide structure where an outer diameter contracts gradually and is prolonged from the edge of main waveguide like a taper configuration in the optical coupling section In the beginning part of contraction waveguides, such as a taper, light shifts to the branching waveguides 13 and 14 by mode coupling from the main waveguide 11, and light shifts to the branching waveguides 2 and 3 by light's shutting up, and a condition's becoming weak and being in a cut-off condition as the termination of contraction waveguide is approached. For this reason, shift of the optical power from the main waveguide to branching waveguide is performed efficiently, and even if it extends gap spacing, increase of superfluous loss can be controlled. Moreover, in this invention, since shift of the light by the cut-off of the main waveguide is also used, mode coupling can be eased and a wavelength dependency can be made small. [0029] Furthermore, since it does not have the expansion structure where the outer diameter of waveguide produces the higher mode in the optical coupling section, the superfluous loss resulting from generating of the higher mode and the mismatching between the modes between waveguides becomes that there is nothing. [0030] As mentioned above, since it has said configuration according to this invention, by setting up the die length of contraction of waveguide width of face, a gap, a taper, etc., expansion waveguide, and its optical coupling section, the yield is good and can make overbranching loss small, the wavelength dependency of a property is made small and the good branching joint optical waveguide circuit of the repeatability of a property is obtained.

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] As mentioned above, the Y branch optical waveguide circuit of a gap [the residual of the core layer of the gap of a lock out part and] shown in drawing 5 becomes blunt, or tended to produce the incompleteness on structures, such as generating of a void, and since branching loss increased and the yield fell, it had a problem at the disadvantageous point on production. Moreover, the branching multiplexing optical waveguide circuit shown in drawing 9 which has a gap between the main waveguide and branching waveguide has the Y branch optical waveguide circuit of drawing 5, and an essential target's same expansion waveguide 22, and makes structure of the optical coupling section the structure which cut the bond part of the main waveguide of a Y branch optical waveguide circuit, and branching waveguide in part in the shape of a straight line. however, with such structure, manufacture of the point of an acute angle about propagation of light it is not only difficult, but In order that the propagation light of the basic mode of the main waveguide 21 serves as the higher mode in the expansion waveguide 22 and may spread by the basic mode by the branching waveguides 23 and 24 further, A sufficiently good branching loss property and a wavelength dependency are not acquired by mutual conversion of propagating mode, and the optical coupling in a gap, but lack also in the stability of reappearance of a branching multiplexing property by them. A difficulty has expression branching loss in that this increases notably, so that the include angle θ with the shaft of the waveguide of the end-face 240 grade of the end face 220 of the expansion waveguide 22, the end face 230 of the branching waveguide 23, and the branching waveguide 24 and the main waveguide 21 to make becomes small especially, and the repeatability of a branching property gets worse greatly. [0010] The incompleteness on manufacture of the waveguide of the optical coupling section of branching multiplexing etc. is eased, the purpose of this invention is easy to manufacture, its superfluous loss is small enough, and its wavelength dependency of superfluous loss is good, and is to offer the high branching multiplexing photoconductive wave circuit of the repeatability of a property.

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MEANS

[Means for Solving the Problem] In the branching multiplexing optical waveguide circuit which has two branching waveguides which this invention combines with the main waveguide and this main waveguide by which the branching multiplexing optical waveguide circuit was formed into the clad on a substrate optically, said main waveguide is characterized by to have the contraction waveguide section to which an edge contracts gradually and extends from the main waveguide, and for said contraction waveguide section and said branching waveguide to approach, to be arranged, and to form the optical-coupling section. Moreover, said contraction waveguide section in said optical coupling section has a taper configuration in a both-sides side, and said branching waveguide is characterized by having the expansion waveguide section of each taper configuration of said main waveguide, and the taper configuration of the hard flow which counters.

[0012] And it is suitable for the contraction waveguide section and the expansion waveguide section of this invention to have spacing of 2.0 micrometers thru/or 3.5 micrometers, and it is suitable for the optical coupling section to consider as die length of 500 micrometers or more.

[0013] Furthermore, in the structure of a branching multiplexing optical waveguide circuit, the gap section blockaded between two branching waveguides is specifically lost, it has the optical coupling section by which the main waveguide and two branching waveguides are arranged by approaching, the main waveguide has the taper configuration to which waveguide width of face becomes narrow gradually in the optical coupling section, and branching waveguide has the taper configuration to which waveguide width of face spreads gradually in the main waveguide and reverse. The die length of the optical coupling section has die length of at least 500 micrometers or more, although the minimum die length needed by the combination of the width of face of the main waveguide of the optical coupling section and two branching waveguides exists. Moreover, in the optical coupling section, spacing (gap) of the main waveguide and two branching waveguides is set as 2.0-3.5 micrometers. Moreover, the minimum waveguide width of face in the optical coupling section is 2 micrometers or less, in order to bring close to the condition of a cut-off and to shift light. Moreover, waveguide width of face and the depth are decided that only a basic mode spreads until the main waveguide results in the optical coupling section.

[0014] Moreover, in the optical coupling section, the propagation direction of the light which spreads the main waveguide and two branching waveguides determines and arranges the width of face of waveguide so that in parallel.

[0015] By losing the gap blockaded between waveguides and having the optical coupling section which approaches with a predetermined gap (gap) and arranges the main waveguide and two branching waveguides, a gap can be extended without increasing branching loss, the gap section becomes blunt, and generating of a ** void can be abolished. Moreover, if the light which spreads the main waveguide by taking structure which was mentioned above in the optical coupling section reaches the optical coupling section, shift will take place between branching waveguides by mode coupling in the beginning. Then, the light of the main waveguide shut up, and since it becomes weak, and a condition eases mode coupling with a strong wavelength dependency and becomes close to the condition of a cut-

off, the wavelength dependency of branching loss has been abolished as light spreads the main waveguide. Furthermore, by setting the die length of the optical coupling section to 500 micrometers or more, shift of perfect optical power can be realized and reduction of branching loss can be aimed at. [0016] Moreover, as mentioned above, when it is made the waveguide width of face and the depth in which the main waveguide can spread only a basic mode, or the propagation direction of the light which spreads the main waveguide and two branching waveguides determines and arranges the width of face of waveguide in a bond part so that in parallel, increase of branching loss can be controlled, and the branching multiplexing optical waveguide circuit which has low loss and a stable property can be produced.

[0017]

[Embodiment of the Invention] Drawing 1 is the block diagram showing the gestalt of 1 operation of the branching multiplexing optical waveguide circuit of this invention.

[0018] The main waveguide 11 has fixed waveguide width of face (W_0) in the die length which is until it results in the optical coupling section 12, and is waveguide which only a basic mode spreads.

[0019] the optical coupling section -- setting -- the main waveguide 11 -- waveguide width of face -- W_0 from -- W_1 It has taper structure which changes gradually ($W_0 > W_1$). Moreover, the branching waveguides 13 and 14 in the optical coupling section 12 have taper structure which changes waveguide width of face to W_{01} ($W_1 < W_{01}$) gradually from W_1 towards differing from the main waveguide. The minimum width of face W_1 of the main waveguide 11 and the branching waveguides 13 and 14 in taper structure W_1 has the desirable way that the light which spreads taper waveguide in the direction in which waveguide width of face becomes narrow is narrow as it can be cut off (2 micrometers or less). Moreover, although each maximum width (W_0 , W_{01}) of the main waveguide in the optical coupling section 12 and branching waveguide and the minimum (W_1 , W_{11}) do not necessarily need to be the same, its one where each waveguide width of face 11, 13, and 14 is the more nearly same is desirable. That is, it is desirable for the shaft of the main waveguide 11 in the optical coupling section and the branching waveguides 13 and 14 to be parallel.

[0020] In the optical coupling section 12, the main waveguide 11 and the branching waveguides 13 and 14 have predetermined spacing (gap), and are separated. In terms of production of waveguide, as for the gap, it is desirable to make it 2.0 micrometers or more, and it is desirable to make it 3.5 micrometers or less from the point of a property. Moreover, the optical coupling section 12 is the die length l_0 which exists in order to make branching loss small. It is above required. Although the die length changes with the combination of the maximum width (W_0 , W_{01}) of the main waveguide 11 in the optical coupling section 12, and the branching waveguides 13 and 14, and the minimum width of face (W_1 , W_{11}), it is desirable to make it at least 500 micrometers or more.

[0021] The branching waveguides 13 and 14 consist of deflection waveguides in which the optical coupling section 12 which has the taper structure mentioned above, and this have radius of curvature r independently. At this time, it may bend with the waveguide width of face W_{01} with the widest width of face of the taper waveguide of a tee 12, and the width of face W of waveguide does not necessarily need to be the same, and its deflection waveguide width of face may be wide. At this time, it is good also as a configuration which turns at taper waveguide independent [the optical coupling section 12] and completely different with the optical coupling section 12, and is connected between waveguides so that it may bend with the taper waveguide section of one branching waveguide and light may spread by low loss between the waveguide sections. Moreover, slanting waveguide which the branching waveguides 13 and 14 leave mutually is sufficient as the deflection waveguide section.

[0022] In the optical coupling section 12, shift of light takes place to each branching waveguides 13 and 14 by mode coupling in the beginning, in the trailer of the main waveguide 11, light will be in a cut-off condition at the termination of the taper configuration of the main waveguide 11, and the light which has spread the main waveguide 11 will shift to each branching waveguides 13 and 14. Thus, the wavelength dependency of branching loss becomes very small by using a cut-off operation for shift of light. Moreover, the parallel thing of the direction of the light which spreads the main waveguide 11 and the branching waveguides 13 and 14 in the optical coupling section 12 is desirable.

[0023] Production of a branching multiplexing optical waveguide circuit as shown in drawing 1 can be performed by the approach shown in drawing 6. Specifically, they are clad 2a and a core layer 3 on a substrate 1 TEOS-O3 Sequential deposition is carried out in system AP-CVD. Subsequently, the unnecessary core layer 3 is removed so that it may become the optical waveguide circuit mentioned above by reactive ion etching. Then, an optical waveguide circuit is produced by depositing cladding layer 2a so that this core layer 3 may be embedded.

[0024] An example of the property calculated to drawing 3 and drawing 4 in the BPM simulation of the overbranching loss using the branching multiplexing optical waveguide circuit by this invention is shown.

[0025] Drawing 3 is the die length l_0 of the optical coupling section 12 of overbranching loss which made the parameter gap between the main waveguide 11 of the optical coupling section, and the branching waveguides 13 and 14. A dependency is shown. The propagation wavelength λ is 1.27 micrometers and relative index difference Δ is the width of face W_0 of 0.40% and the main waveguide 11. 3 micrometers, The maximum width W_0 of the main waveguide 11 in the optical coupling section 12, and the branching waveguide 13, The die length of the waveguide for W_0 turning at the 3-micrometer ($W_0 = W_01$) minimum width of face W_1 and W_11 with the optical coupling section 12 of 1 micrometer ($W_1 = W_11$) and the branching waveguides 13 and 14, and connecting waveguide is 500 micrometers. By 500 micrometers or more, the value with as small overbranching loss as 0.2dB or less is acquired for the die length of the optical coupling section 12.

[0026] Drawing 4 shows the propagation wavelength dependency of the overbranching loss which made the parameter gap between the main waveguide 11 of the optical coupling section 12, and the branching waveguides 13 and 14. The die length l_0 of the optical coupling section The conditions of 500-micrometer others are the same as drawing 3. The value with very as small overbranching loss as 0.2dB or less is acquired by the wavelength of 1.27 micrometers to 1.57 micrometers.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is drawing showing the gestalt of 1 operation of the branching multiplexing optical waveguide circuit of this invention.

[Drawing 2] It is drawing showing the sectional view in A-A' of the gestalt of this operation.

[Drawing 3] It is drawing showing an example of the property of the bond part die-length (l₀) dependency of the superfluous loss by the BPF simulation in the gestalt of this operation.

[Drawing 4] It is drawing showing an example of the property of the wavelength dependency of the superfluous loss by the BPF simulation in the gestalt of this operation.

[Drawing 5] It is drawing showing an example of the conventional branching multiplexing optical waveguide circuit.

[Drawing 6] It is drawing showing an example of the manufacture approach of a branching multiplexing optical waveguide circuit.

[Drawing 7] It is drawing showing the sectional view in B-B' of the conventional branching multiplexing optical waveguide circuit.

[Drawing 8] It is drawing showing the sectional view in B-B' of the conventional branching multiplexing optical waveguide circuit.

[Drawing 9] It is drawing showing other examples of the conventional branching multiplexing optical waveguide circuit.

[Description of Notations]

1 Substrate

2 Clad

3 Core Layer

11 21 Main waveguide

12 Optical Coupling Section

13, 14, 23, 24 Branching waveguide

15 Connection

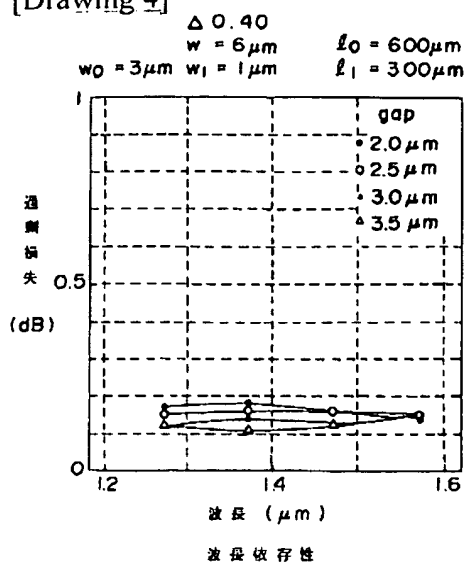
22 Expansion Waveguide

24 Branch Point

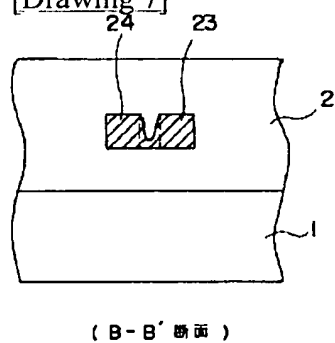
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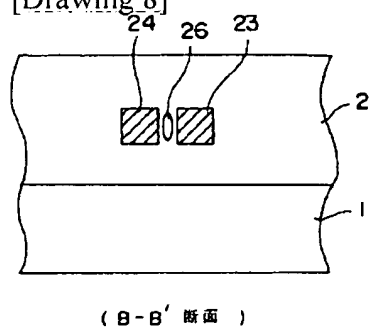
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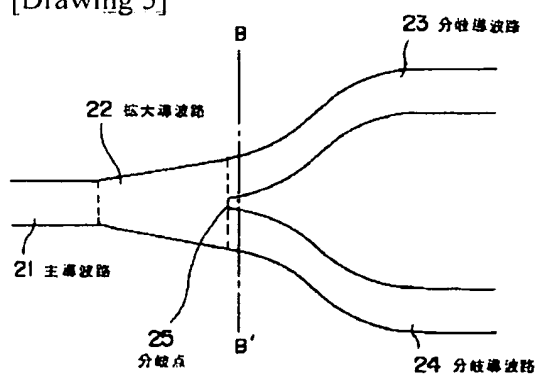
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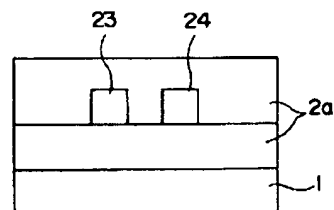
[Drawing 8]



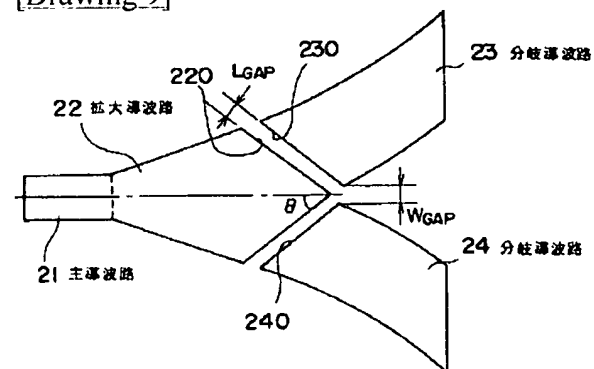
[Drawing 5]



(a)



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